The Journal of Animal & Plant Sciences, 26(2): 2016, Page: 475-480
ISSN: 1018-7081

INVESTIGATION OF THE AIR POLLUTION TOLERANCE INDEX (APTI) USING SOME PLANT SPECIES IN AHVAZ REGION

A. Gholami[1*], A. Mojiri[2] and H. Amini[3]

[1]Department of Soil Science, College of Agriculture, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
[2]School of Environmental Science and Engineering, Shanghai Jiao Tong University, 800 Dongchuan RD. Minhang District, Shanghai, China
[3]Department of Soil Science, College of Agriculture, Isfahan Branch, Islamic Azad University, Isfahan, Iran
[*]Corresponding Author's email: ali.gholami54@gmail.com; a.gholami@iauahvaz.ac.ir

ABSTRACT

Air pollution is one of the main environmental problems in many cities around the world. Controlling this kind of pollution is more complex than other environmental challenges. Many plants can absorb and save some of the environmental pollutants through their leaves. Therefore, air pollution tolerance index (APTI) was tested in polluted and blank areas in six plant species, namely, *Conocarpus*, *Myrtus, Prosopis, Eucalyptus, Ziziphus,* and *Lebbek*, which are abundant in the Ahvaz region during 2014. Dust deposition on leaf surfaces was determined to observe the extent of particulate deposition. The highest and the lowest deposition rates were observed in *Myrtus* (maximum 80.3 $g.m^{-2}$ in polluted site) and *Lebbek* (minimum 10.7 $g.m^{-2}$ in blank site), respectively. The APTI was calculated to be 4.97 for *Prosopis,* 5.25 for *Ziziphus*, 6.24 for *Lebbek*, 6.59 for *Conocarpus*, 6.77 for *Eucalyptus* and 7.80 for *Myrtus* in blank site and 4.57 for *Prosopis,* 4.82 for *Ziziphus*, 5.79 for *Lebbek,* 5.84 for *Eucalyptus*, 6.30 for *Conocarpus* and 7.21 for *Myrtus* in the polluted area at the end of study. The APTI showed that *Myrtus* is resistant to plant pollution, whereas *Prosopis* is sensitive to plant pollution. In addition, the results of assessment of the above mentioned index showed that plants with higher APTI can be used as reducers of pollution and plants with lower APTI can be used to measure air pollution.

Keywords: Air pollution tolerance index, Total chlorophyll content, Relative water content, Ahvaz region.

INTRODUCTION

The quality of air affects the quality of life and human respiration, and the quality of air can change as the weather changes day to day and even hour to hour. Our environment comprises a very large and intertwining complex of water, air, soil, and biological life, which includes nature and all living beings; the environment is affected by human activities and vice versa (Tabatabae *et al*., 2012). The quality of air has an impact on a human being's quality of life. Air pollution is a result of industrialization and urbanization and is a major problem of cities (Hamraz *et al*., 2014). Natural factors, such as windstorms, extreme temperature, and dust, add particles and gases to the air; also, human activities, industrial and agricultural plants, and vehicles are factors that result in the presence of such materials into the air.

Across the Middle East, people have always contended with excessive heat, dust storms, shortage of rainfall, and harsh geography; thus, air pollution has more effects on people's lives in this region (United Nations Environment Program, 2002). Among the damages caused by air pollutants, the most significant ones occur in the leaves of plants. These damages include chlorosis and necrosis of leaves. In fact, plants exposed to pollutants show a wide variety of responses (Deeplashimi *et al*., 2013). Plant species act as natural bioindicators of atmospheric pollutants. Plants can be used as bioassay systems for monitoring atmospheric pollutants (Feder, 1978). In literature, some researchers (Feder, 1978; Hasegawa *et al*., 2002; Simon *et al*., 2006) have investigated air pollutants through plants.

In the present study, four parameters (ascorbic acid, total chlorophyll content, relative water content, and active acidity) were identified and expressed together in one formula to evaluate the sensitivity of plants to air pollutants (Kotecha *et al*., 2007). Plants' reaction to air pollution is determined by the air pollution tolerance index (APTI) and APTI determines the plant's ability to fight against air pollution (Vinita *et al*., 2010). Therefore, to improve air quality and minimize the pollution in the Ahvaz region, the APTI was evaluated, and the air pollution resistant species were identified.

MATERIALS AND METHODS

Study area: This research has been done in Ahvaz, Iran (31°19′13″N to 48°40′09″E; Figure 1). Ahvaz is one of the most polluted areas of the world. In 2013, the World Health Organization ranked Ahvaz as the most air-polluted city in the world (WHO, 2013; Goudarzi *et al*. 2014 and http://science.time.com/2013/10/18/the-10-most-polluted-cities-in-the-world/). This region has a hot and humid climate and abundance of dust. The highest temperature recorded during this study was 49ºC during spring season, whereas lowest temperature recorded was 35ºC during summer. The average annual rainfall recorded was 121 mm, mostly occurring during the winter season. The altitude of Ahvaz is 18 m above free sea level. Moreover, because of the existence of industrial factories and power plants, the region is industrially polluted.

Fig. 1. Study Area

Sampling and analytical method: This study was conducted on six plant species, namely, *Conocarpus, Myrtus, Prosopis, Eucalyptus, Ziziphus, and Lebbek,* which are abundant in the Ahvaz region, to evaluate their APTIs. Six plant species were selected during the spring and summer seasons of 2014 in May and September. This study conducted plant sampling in two areas: polluted and blank areas. Sampling was done, and five trees were selected from each species randomly. Samples were collected from a height of approximately 1 m from the ground in four directions. Samples were then mixed and transported to the laboratory. The active acidity of the leaf extract was measured by a digital pH meter; the amount of ascorbic acid was measured by titration method 2 and 6 dichlorophenolindophenol; the content of relative water of the leaf was measured by weight method; and the total chlorophyll content was measured by a spectrophotometer after extraction with 80% acetone (Amini *et al*., 2009). The APTI was calculated by the following formula (Sing and Rao, 1983).

$$APTI = \frac{A(T+P)+R}{10}$$

Where A: Ascorbic acid content ($mg.gr^{-1}$); T: The total chlorophyll content ($mg.gr^{-1}$); P: The amount of leaves active acidity (pH); R: Relative water content (%).

For collection and measurement of dust load in plants leaf surface, the mature leaf samples from different heights were randomly collected from each plant and placed in a beaker and washed thoroughly by a hairbrush with distilled water. This water solution was then completely evaporated in an oven at 100℃ and weighed with an electronic balance to record the total dust. The leaf area was measured with a digital leaf area meter. The amount of dust was calculated by the following formula (Prusty *et al*., 2005).

$W = (w_2 - w_1) / n$

Where W = amount of dust ($mg.cm^{-2}$); w_1 = initial weight of beaker with dust (mg); w_2 = final weight of the beaker with dust (mg); n = total area of the leaf (cm^2).

RESULTS AND DISCUSSION

The biochemical characteristics of leaf extract and the APTI parameter of selected plants in the polluted and blank areas for the months of May and September are shown in Tables 1 to 4, respectively.

pH: In the current study, the pH values in leaves ranged from 5.05 to 6.36 in blank area, 5.08 to 6.16 in polluted area in May and 5.28 to 6.85 in blank area, 5.45 to 7.00 in polluted area in September were determined to be maximum and minimum for *Myrtus* and *Eucalyptus*, respectively. Abedesfahani *et al*. (2013) reported that a high level of pH in a plant improves its resistance to air pollution. The pH results in this research to notify that the *Myrtus* with 7.00 is resistant to plant pollution in polluted area. However, most of the plants show pH in the range of 5 to 7. It is reported that, in the presence of an acidic pollutant, the leaf pH is reduced and the reducing rate is more in sensitive plants compare to that in tolerant plant species (Scholz and Reck, 1977).

Relative water content (RWC): High water content within a plant body helps maintain its physiological balance under stressful conditions, such as exposure to air pollution (Innes and Haron, 2000). Under air polluted conditions, transpiration rates are frequently high, which may lead to desiccation. Therefore, the maintenance of RWC by the plant may determine its relative tolerance to pollution (Verma, 2003). Increased RWC in a particular species improves its drought tolerance. Thus, the high RWCs of plants in an industrial site sample may be responsible for the normal function of plant biological processes (Rai *et al*., 2013). The leaf RWC ranges in 6 plant species were from 39.86% to 66.24% in blank area, 37.99% to 60.01% in polluted area in May and 40.86% to 68.22% in blank area, 35.88% to 58.12% in polluted area in September. The highest and lowest values were obtained from *Myrtus* and *Prosopis,* respectively. This difference in RWC is due to the difference among plant species. Nwadinigwe (2014) found that RWC was higher in the experimental plants than in the control plants. Dedio (1975) reported that the higher RWC is to be advantageous for drought resistance.

Ascorbic acid: Ascorbic acid is vital in cell wall synthesis, defense, and cell division. It plays an important role in photosynthetic carbon fixation. Because of its importance, ascorbic acid is used as a factor in the formula used to calculate APTI (Nwadinigwe, 2014). The Ascorbic acid ranges ($mg.g^{-1}$) in 6 plant species were from 1.33 to 1.58 in blank area, 1.45 to 1.98 in polluted area in May and 1.35 to 1.58 in blank area, 1.47 to 1.99 in polluted area in September. The highest and lowest values were obtained from *Myrtus* and *Eucalyptus*, respectively. Ascorbic acid is an antioxidant that increases the resistance of plants against air pollutants (Deepalakshmi *et al*., 2013). Plant species with high amount of ascorbic acid are considered to be tolerant to air pollutants (Keller and Schwager, 1977).

Table 1. Results of the biochemical analysis of six plant species from blank area in May, 2014

Plant	pH	Relative water content (%)	Ascorbic acid content ($mg.g^{-1}$)	Total chlorophyll content ($mg.g^{-1}$)	APTI	Dust accumulation ($g.m^{-2}$)
Eucalyptus	5.05	60.78	1.33	0.27	6.17	16.5
Lebbek	6.36	53.48	1.39	0.28	6.08	10.7
Zizyphus	6.09	39.86	1.35	0.24	4.69	12.8
Conocarpus	5.27	57.92	1.52	0.18	6.26	14.1
Prosopis	5.55	40.52	1.44	0.16	4.35	20.2
Myrtus	5.53	66.24	1.58	0.18	6.99	30.2

Table 2 Results of the biochemical analysis of six plant species from polluted area in May, 2014

Plant	pH	Relative water content (%)	Ascorbic acid content ($mg.g^{-1}$)	Total chlorophyll content ($mg.g^{-1}$)	APTI	Dust accumulation ($g.m^{-2}$)
Eucalyptus	5.08	55.21	1.45	0.18	6.28	27.9
Lebbek	6.11	51.77	1.48	0.20	6.11	15.9
Zizyphus	5.57	38.97	1.72	0.12	4.97	20.8
Conocarpus	5.30	55.34	1.65	0.13	6.43	22.7
Prosopis	6.10	37.99	1.46	0.17	4.71	44.3
Myrtus	6.16	60.01	1.98	0.11	7.24	53.2

Table 3. Results of the biochemical analysis of six plant species from blank area in September, 2014

Plant	pH	Relative water content (%)	Ascorbic acid content ($mg.g^{-1}$)	Total chlorophyll content ($mg.g^{-1}$)	APTI	Dust accumulation ($g.m^{-2}$)
Eucalyptus	5.28	60.25	1.35	0.24	6.77	25.5
Lebbek	6.85	52.48	1.40	0.26	6.24	15.8
Zizyphus	6.15	43.49	1.45	0.13	5.25	18.9
Conocarpus	5.45	57.25	1.52	0.16	6.59	17.5
Prosopis	6.34	40.86	1.36	0.22	4.97	25.1
Myrtus	6.05	68.22	1.58	0.15	7.80	35.1

Table 4. Results of the biochemical analysis of six plant species from polluted area in September, 2014

Plant	pH	Relative water content (%)	Ascorbic acid content ($mg.g^{-1}$)	Total chlorophyll content ($mg.g^{-1}$)	APTI	Dust accumulation ($g.m^{-2}$)
Eucalyptus	5.45	50.22	1.47	0.10	5.84	55.5
Lebbek	6.98	47.23	1.50	0.11	5.79	40.8
Zizyphus	6.45	36.87	1.73	0.09	4.82	54.8
Conocarpus	5.75	53.18	1.68	0.08	6.30	53.6
Prosopis	6.55	35.88	1.48	0.10	4.57	60.6
Myrtus	7.00	58.12	1.99	0.05	7.21	80.3

Total chlorophyll content: The amount of total chlorophyll (in $mg.g^{-1}$ of fresh weight) in 6 plant species were from 0.16 to 0.28 in blank area, 0.11 to 0.20 in polluted area in May and 0.13 to 0.26 in blank area, 0.05 to 0.11 in polluted area in September. The lowest amount of total chlorophyll was 0.06 that belong to *Myrtus* in polluted area. The amount of total chlorophyll was decreased in September comparing to May in each both areas, blank and polluted zone but in the polluted zone was sharply. It is due to increase air pollution effected of dust. This result according to Allen *et al*. (1987) opinion shows that the chlorophyll content decreases with increasing pollutant level because certain pollutants generally reduce the total chlorophyll content. Santosh *et al*. (2008) reported that a high amount of chlorophyll in plants increases air pollution tolerance. Chandawat *et al*. (2011) reported that the chlorophyll contents of plants varied with the pollution status of the area, as well as the tolerance and sensitivity of the plant species. Chlorophyll is known as an important stress metabolites and higher chlorophyll content in plants might favor tolerance to pollutants (Joshi *et al*., 1993).

Air Pollution Tolerable Index (APTI): APTI is the inherent quality of plants to counter air pollution stress, which is presently a primary concern, particularly in industrial areas. Therefore, the APTI needs to be monitored and checked in predominant species that are present in polluted and non-polluted areas (Rai *et al*., 2013). The APTI values were estimated using the four biochemical parameters in plant leaves, namely, RWC, total chlorophyll content, pH, and ascorbic acid value. They can be used as predictors of air quality.

The APTI values calculated for each plant species are presented in table 1 and 3 for blank and table 2 and 4 for polluted study areas among two months. Those tables clearly show that *Myrtus* has maximum APTI and *Prosopis* has minimum APTI. In polluted area, APTI values are higher compared to blank, in the month of May. In contrast, APTI values are lower in September, indicating the higher tolerance in this season. Plants that have higher APTI values are tolerant to air pollution, whereas plants with lower APTI values show generally lower tolerance and sensitive to air pollutants (Singh *et al*., 1991). A suitable evaluation can be done on the resistance and susceptibility of plants to air pollution using the APTI index (Sakhravi and Gholami, 2014). Determining the tolerant and susceptible species is essential for the reduction of pollution in urban and industrial areas (Marfavipourahmadi, 2014). Results of another study agreed that determining the tolerant and susceptible species is essential to reduce pollution in these areas (Dehghanpour, 2014).

Dust accumulation on Leaf Surface: Amount of dust accumulation on leaf surfaces was show in Table 1 and 3 for the month of May and September, and Table 2 and 4 for blank and polluted areas, respectively**.** Highest dust retaining put in *Myrtus* (80.3 $g.m^{-2}$) in September at polluted area and the lowest show in *Lebbek* (10.7 $g.m^{-2}$) in the month of May at blank area. Verma, 2003 declare the dust-filtering ability of the plant species was correlated with their foliar surface characteristics. The morphological characteristics which alone or in combination play a significant role in the interception of dust load from the ambience are: shape, size (leaf area in cm_2) and orientation of leaf on the main axis, surface nature (smooth/striate), the presence or absence of wax deposition.

Conclusions: Given the APTI results, the suitable plant species can be selected for use in polluted areas. When the APTI is known, selecting the proper species for use in polluted regions is possible. Plants with high APTI can be used as pollution reducers, whereas plants with low APTI can be used to measure of air pollution. This study can conclude that *Myrtus* has the highest resistance against air pollution compared to the other species because it has the highest amount of Air Pollution Tolerable Index equal and above to 7 in each month. Then, *Conocarpus* with an index figure equal to 6.26, *Eucalyptus* 6.17, *Lebbek* 6.08, *Ziziphus* 4.69 and *Prosopis* 4.35 is following. *Ziziphus* was selected as the plant susceptible to air pollution in this study. The lowest pollution tolerable index was calculated equal to 4.35. Abedesfahani *et al*., (2013) reported that the APTI determination provides a reliable method for screening large number of plants with respect to their susceptibility to air pollutants. The method is simple and convenient to adopt under field conditions without adopting any costly environmental monitoring gadgets. The sensitive plants can be used as indicators and tolerant plants can be used as a prick for air pollutants. Plants have been categorized into groups according to their degree of sensitivity toward and tolerance of various air pollutants (Khan and Abbasi, 2002). Tolerances to air pollution alter from species to species, depending on plants capacity to endure the effect of pollutants without exhibition any external damage.

Acknowledgments: This article was extract of research project with title: Evaluating the Soil Physiochemical and Nutrient Constraints and Anticipate Performance Index (API) on Trees and Shrubs Suggested for Ahvaz Green Belt Development. The authors wish to thank the Ahvaz branch—Islamic Azad University for the financial support. The authors would like to thank all the editors and reviewers for their comments in the development and improvement of this paper.

REFERENCES

Abedesfahani, A., H. Amini, N. Samadi, S. Kar, M. Hoodaji, M. Shirvani and K. Porsakhi (2013). Assesment of air pollution tolerance index of higher plants suitable for green belt development in east of Esfahan City, Iran. J. Ornam. and Hort. P. 3(2): 87-94.

Allen (Jnr), L. H., K. L. Boote and J. W. Jones (1987). Response of vegetation to rising carbon dioxide photosynthesis, biomass and seed yield of soybeans. Giob. Biogeochem. Cycle. 13: 1-44.

Amini, H., M.M. Sadegheyan, M. Arajshiravani, and A. Banitaba (2009). Assessment of air pollution tolerable index for some plant species considered for green belt development in the city of Isfahan. Proc. natl. conf. of new ideas in agriculture, Isfahan, Iran. pp. 57-60.

Chandawat, D.K., P.U. Verma and H.K. Solanki (2011). Air pollution tolerance index of three spaces at cross roads of Ahmedabad City. Life Sci. Leaf. 20: 935-943.

Dedio, W. (1975). Water relations in wheat leaves as screening tests for drought resistance. Can. J. Plant Sci. 55: 369–378.

Deepalakshmi, A.P., H. Ramakrishnaiah, Y.L. Ramachandra, and R.N. Radhika (2013). Roadside Plants as Bio-indicators of Urban Air Pollution. IOSR J. of Environ. Sci. Toxic. and Food Tech. (IOSR-JESTFT), 3: 10-14.

Dehghanpour, M., A. Gholami and A. Abtahi (2014). Assessment of Air Pollution Tolerance Index (APTI) in three plant species in Khouzestan. M.Sc. thesis (unpublished). Deptt. of Soil Sci., Sci. and Res. Branch, Islamic Azad Univ. Shiraz, Iran.

Feder, W.A. (1978). Plants as bioassay systems for monitoring atmospheric pollutants. Environ. Health Prospect. 27: 139-147.

Goudarzi, G., S. Geravandi, M. Vosoughi, M.J. Mohammadi, A. Neisi, and S.S. Taghavirad, (2014). Cardiovascular Deaths Related To Carbon Monoxide Exposure In Ahvaz, Iran. Iran. J. Health, Safety & Environ. 1(3): 126-131.

Joshi, O.P., K. Pawar, and D.K. Wagela. (1993). Air quality monitoring of Indoor city with special referenceto SO_2 and tree barks pH. J. Environ. Biol. 14: 157–162.

Hamraz, H., A. Sadeghi-Niaraki, M. Omati, and N. Noori. (2014). GIS-Based Air Pollution Monitoring using Static Stations and Mobile Sensor in Tehran/Iran. Int. J. Sci. Res. in Environ. Sci. 2(12): 435-448.

Hasegawa, Y., H. Uchida, S. Asada, T. Katsube and T Oyabu (2002). Investigation of air pollution purification process by a bioelectrical potential analysis. Proc. Indoor Air.

Innes, J. L., and A. H. Haron. (2000). Air pollution and the forests of developing and rapidly industrializing regions. CAB. I. Wallingford, UK.

Keller, T., and H. Schwager (1977). Air pollution and ascorbic acid. Europ. J. Forest Pathol. 7: 338–350.

Khan, F. I., and S.A. Abbasi (2002). Design of greenbelt for an industrial complex based on mathematical modeling. Environ. Technol. 23 (7): 799–811.

Kotecha, M., K. Naik, and L. Abraham (2007). Study of Air pollution tolerable index (APTI) and distribution pattern by using importance value index (IVI) of plants in disturbed and undisturbed locality around Anand city (INDIA). Carpathi. J. Earth and Environ. Sci. 9(1): 115-120.

Marfaviporahmadi, A. and A. Gholami (2014). Assessment of air pollution tolerable index based on three species in urban, industrial and control zones in Ahvaz. M.Sc. thesis (unpublished). Deptt. of Soil Sci., Sci. and Res. Branch, Islamic Azad Univ. Ahvaz, Iran.

Nwadinigwe, A.O. (2014). Air pollution tolerance indicate of some plants around AMA industrial complex in Enugu State, Nigeria. African J. Biotech. 13(11): 1231-1236.

Prusty, B.A., C.A. Mishra, and P.A. Azeez (2005). Dust accumulation and leaf pigment content in vegetation near the national highway at Sambalpur, Orissa, India. Ecotoxic. and Environ. Safety, 60: 228-235.

Sakhravi, A. and A. Gholami (2014). Assessment the Conocarpus plant in the shoreline of Karoon River. M.Sc. thesis (unpublished). Deptt. of Soil Sci., Sci. and Res. Branch, Islamic Azad Univ. Ahvaz, Iran.

Santosh, K., B. Prajapati and D. Tripathi (2008). Anticipated Performance Index of some tree species considered for green belt development in and around an urban area: A case study of Varanasi city, India. J. Environ. Manage. 88: 1343–1349.

Scholz, F., and S. Reck (1977). Effects of acids on forest trees as measured by titration in vitro, inheritance of buffering capacity in Picea abies. Water, Air and Soil Pollu. 8: 41-45.

Simon, E., M. Simini, and D.R. DecoTeau (2006). Using Plants to Monitor Air Pollution. Purdue Univ. West Lafayette, Indiana, 47907.

Singh, S.K. and D.N. Rao (1983). Evaluation of plants for their tolerance to air pollution. Proc. Int. Symp. on air pollution control. IIT Delhi pp. 218-224.

Singh, S.K., D.N. Rao, M. Agrawal, J. Pande, and D. Narayan (1991). Air pollution tolerance index of plants. J. Environ. Manage. 32: 45-55.

Rai, P.K., L.S.S. Panda, B.M. Chutia, and M.M. Singh (2013). Comparative assessment of air pollution tolerance index (APTI) in the industrial (Rourkela) and non-industrial area (Aizawl) of India: An Eco management approach. African J. Environ. Sci. and Tech. **7**(10): 944-948.

Tabatabae, M., M.T. Kariminejad and A. Gholami (2012). Study of concentration and determining the origin of the heavy metals in the soils of Iran National Steel Industrial Group Complex. M.Sc. thesis (unpublished). Deptt. of Environ. Mang. Sci. and Re. Branch, Islamic Azad Univ. Ahvaz, Iran.

United Nations Environment Program (2002). Air Quality and Atmospheric Pollution in the Arab Region. The United Nations Economic and Social Commission for Western Asia and the Unit. Nat. Environ. Prog. Regional Office for West Asia.

Verma, A. (2003). Attenuation of automobile generated air pollution by higher plants. Dissertation, (unpublished). Univ. of Lucknow.

Vinita, P., B.D. Tripathi and V.K. Mishra (2010). Evaluation of Anticipated Performance Index of some tree species for green belt development to mitigate traffic generated noise. UFUG-25195; No. of Pages 6.

World Health Organization-WHO (2013). Report: Air Pollution Causes Cancer.